1. Title: Enhancement of the Cornell Decision Support System for potato and tomato late blight.

2. Project Leader:

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3. Cooperators:

Ian Small (graduate student, Department of Plant Pathology and Plant-Microbe Biology
Laura Joseph (retired from the Crops and Soil Sciences department)

4. Abstract:

Late blight of potato and tomato is one of the most serious and dramatic of plant diseases. The pandemic on tomatoes in 2009 throughout the Northeast was a reminder that this disease can still erupt to cause severe damage to tomatoes and potatoes. The Cornell Decision Support System (DSS) is a web-based tool that aids growers to avoid calamity caused by this disease. The DSS integrates effects of weather, host resistance, pathogen presence, pathogen characteristics and fungicide to enable effective and low pesticide suppression of this disease. The enhancements developed as result of this IPM grant were: i) to expand the number of fungicides available in the DSS; ii) to modify recommendations based on the increased number of fungicides. The enhancements and modifications were demonstrated to be effective in a field experiment. Thus, the DSS is now a more useful tool in the constant struggle against this severe disease.

5. Background and justification:

A significant goal of many plant protection scientists is to reduce the use of pesticides in agriculture. Some crops use huge amounts of pesticide. For example, farmers in the USA used more than 2000 tons of fungicide to suppress potato diseases in 2001. We have been interested for some years in using models to facilitate reductions in pesticide use. Weather has a dramatic effect on many diseases including diseases of potato and tomato. The linkage of models to weather data rapidly via the internet can provide information that can inform real-time management decisions concerning pesticide application. We have developed a system of models, in a decision support system (DSS) that is available on the internet. It includes disease forecasts, a simulation model of the late blight disease, and a communication system. This project expanded the DSS to: i) include resistance characteristics of additional cultivars of tomato and ii) include fungicides (mefenoxam first) in addition to chlorothalonil. We project that use of the system can enable a reduction in fungicide use of up to 15-20%.

Potato growers have long been aware of the dangers of late blight and have supported this effort by helping to evaluate early forms of the DSS. One grower (Gary Mahany) has purchased his own weather station so that he can use weather data on his farm. The Empire State Potato Growers have supported the development of the DSS over the years and again in 2012 have contributed $5000 to support its development.

However, the tomato late blight pandemic in 2009 in the northeastern USA caused tomato growers to also become very aware of late blight. This pandemic provided impetus to expand the DSS to include tomato late blight as well as potato late blight. We have demonstrated that the pandemic strain and the other widespread strain are both sensitive to mefenoxam, an especially effective fungicide to suppress strains sensitive to it. (Unfortunately, the previously dominant strains have been resistant to mefenoxam). Both potato and tomato late blight are part of a large AFRI grant in which 20+ cooperators (including the PI) are collaborating to enhance to effective suppression of late blight on both potatoes and tomatoes.

There have been many improvements to the DSS, but many also remain to be accomplished. In the research supported by this grant we included the effects of mefenoxam in the DSS; we also identified the effects of diverse fungicides on tomato cultivars of different resistance to late blight. (We also assisted the evaluation of 35 tomato cultivars in terms of their resistance to late blight. However, this effort was supported largely by other funds.)

This project addressed the following High Priority commodity and IPM priorities.

- "Improve and expand weather-based … disease forecasting models"
- "Develop decision systems for diseases … that are based on weather data and compatible with the currently owned electronic weather sensors."
- "Optimize pesticide efficacy evaluations by timing treatments based on action thresholds"
- "Breeding to improve … disease management."
- "Demonstration projects using late blight forecasting system."
- "Develop information for improving late blight forecasting in tomatoes"

6. Objectives:

i) Incorporate mefenoxam as one of the fungicides available in the DSS.
ii) Evaluate the resistance of important tomato cultivars to late blight in the field.
iii) Project evaluation.

7. Procedures:

i) A model (already constructed for mefenoxam dynamics in plants) has been incorporated into the DSS by working with programmer Laura Joseph. The effects of this fungicide as well as most of the other popular fungicides were incorporated by modifying the Simcast model in the DSS.

ii) In collaboration with new graduate student Zach Hansen and Chris Smart, field experiments were conducted in Freeville with >35 tomato cultivars. We assisted with these experiments and the results will be reported separately. There were clear differences among the tomato cultivars.

iii) Project evaluation will occur in the short term and in the long term. In the short term there are two measures of success: i) incorporation of mefenoxam in the late blight forecast (Simcast) in the DSS; and ii) demonstration in field experiments that the DSS enables effective, efficient (minimal fungicide) suppression of late blight.

8. Results and discussion:

i) Incorporate mefenoxam as one of the fungicides available in the DSS.

The effects of mefenoxam (Ridomil) and most of the other popular late blight fungicides (Table 1) were evaluated in field experiments in 2012 (pictured below).

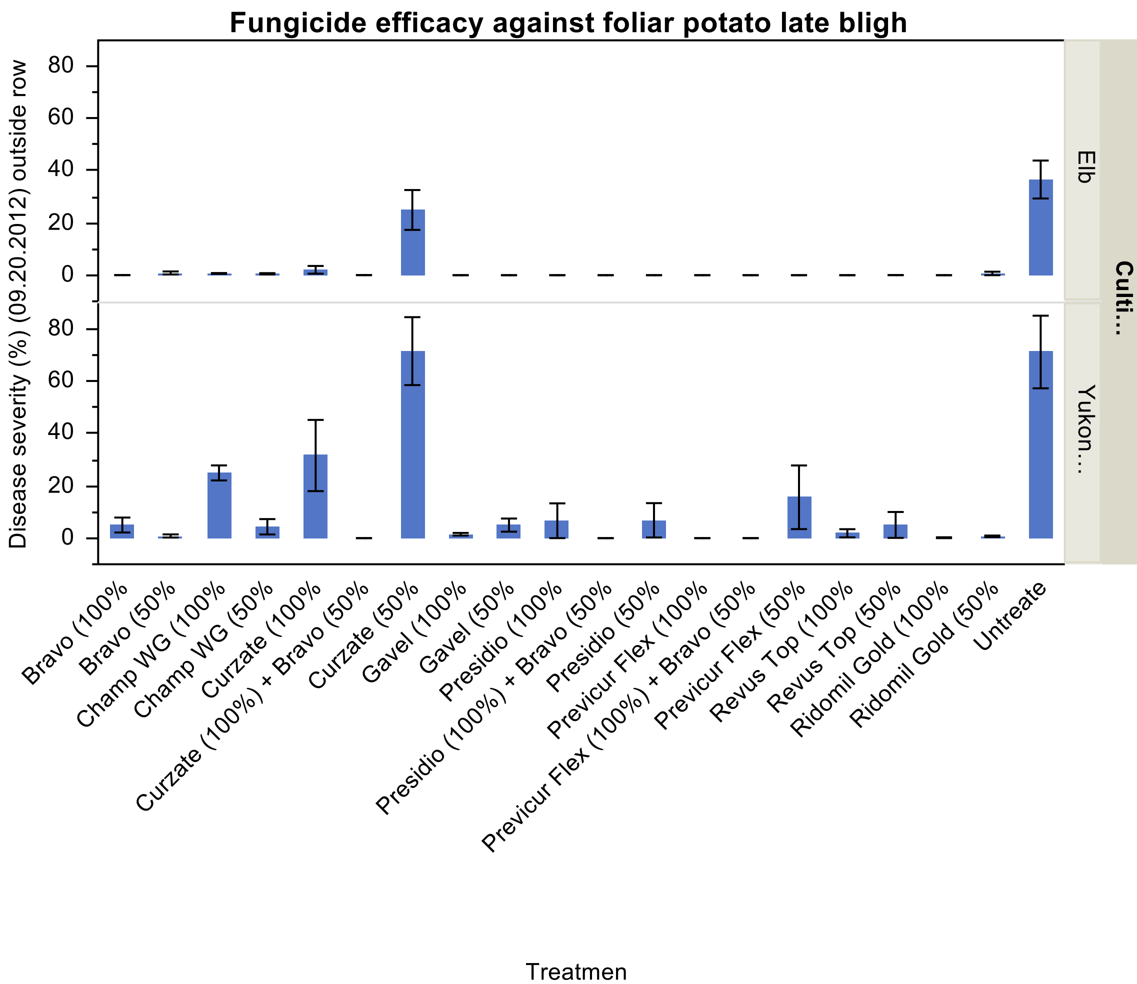
Field plots

Table 1. Treatment and rate of product per acre for fungicides evaluated in field trials

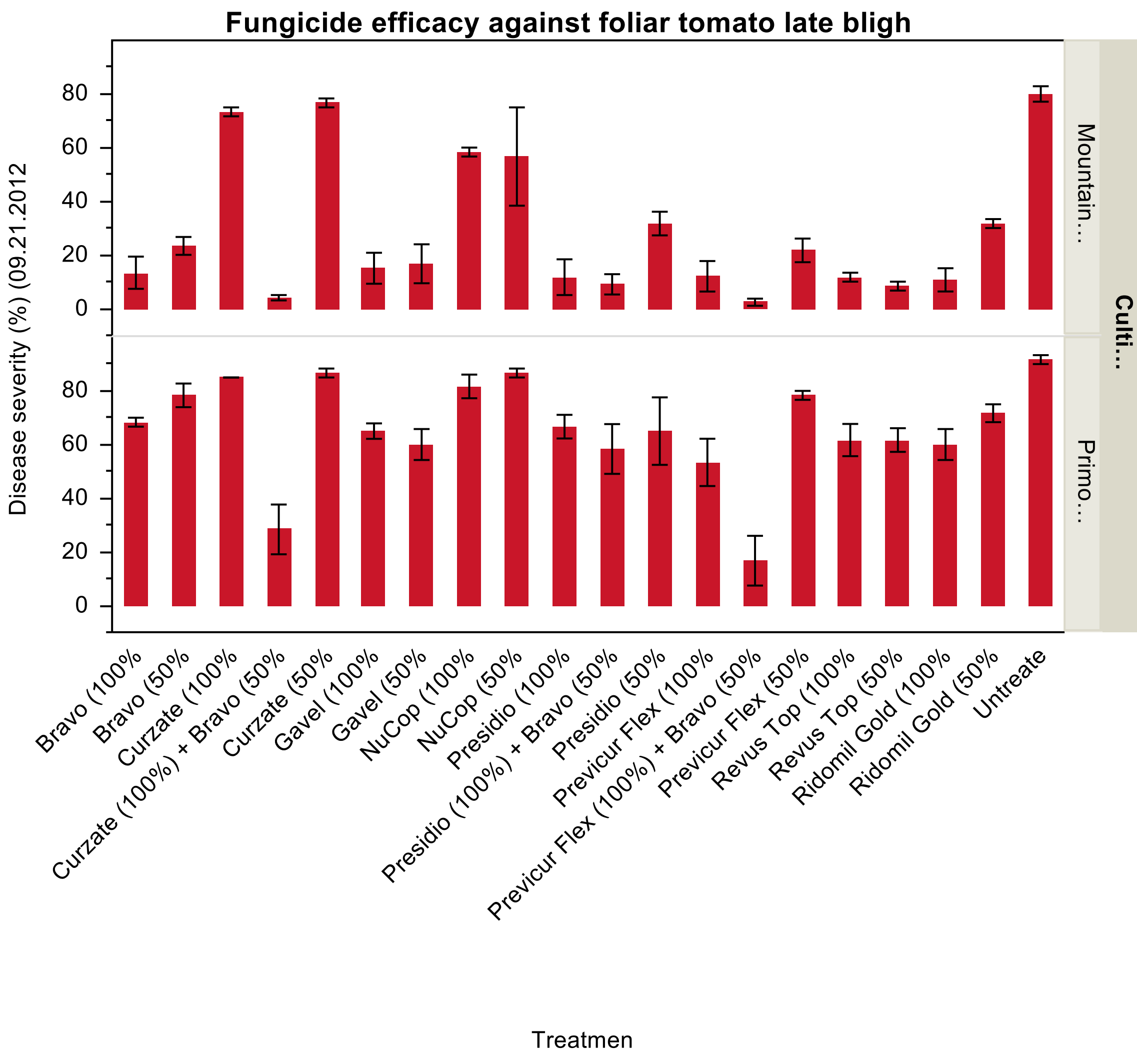
Treatment	Product (% of full label rate)	Active ingredient (%)	Rate per acre
1	Bravo WS (100%)	chlorothalonil (54%)	1.5 pt
2	Bravo WS (50%)	chlorothalonil (54%)	0.75 pt
3	NuCop 3L (100%)	copper hydroxide (37.5%)	6.5 pt
4	NuCop 3L (50%)	copper hydroxide (37.5%)	3.25 pt
5	Curzate 60 DF (100%)	cymoxanil (60%)	3.2 oz.
6	Curzate 60 DF (50%)	cymoxanil (60%)	1.6 oz.
7	Gavel 75 DF (100%)	mancozeb (66.7%) + zoxamide (8.3%)	2.0 lb
8	Gavel 75 DF (50%)	mancozeb (66.7%) + zoxamide (8.3%)	1.0 lb
9	Previcur Flex (100%)	propamocarb hydrochloride (66.5%)	1.2 pt
10	Previcur Flex (50%)	propamocarb hydrochloride (66.5%)	0.6 pt
11	Ridomil Gold SL (100%)	mefenoxam (45.3%)	3.2 oz.
12	Ridomil Gold SL (50%)	mefenoxam (45.3%)	1.6 oz.
13	Revus Top (100%)	mandipropamid (21.9%) + difenoconazole (21.9%)	7.0 oz.
14	Revus Top (50%)	mandipropamid (21.9%) + difenoconazole (21.9%)	3.5 oz.
15	Presidio (100%)	fluopicolide (39.5%)	4 oz.

16	Presidio (50%)	fluopicolide (39.5%)	2 oz.
17	Curzate (100%) + Bravo (50%)	cymoxanil (60%) + chlorothalonil (54%)	3.2 oz. + 0.75 pt.
18	Previcur Flex (100%) + Bravo (50%)	propamocarb hydrochloride (66.5%) + chlorothalonil (54%)	1.2 pt. + 0.75 pt.
19	Presidio (100%) + Bravo (50%)	fluopicolide (39.5%) + chlorothalonil (54%)	4 oz. + 0.75 pt.
20	Unsprayed check		

Effects were assessed on two tomato cultivars and on two potato cultivars. There were clear differences among fungicides as illustrated in the figures below.



- Each error bar is constructed using 1 standard error from the mean.
- Cultivar 'Yukon gold' is classified as susceptible to foliar late blight. Cultivar 'Elba' is classified as moderately resistant to foliar late blight.
- Percentage shown after treatment name indicates percentage of registered full label rate (NY)
- Outside rows were uninoculated and relied on secondary infection from inner rows.



These data and other data available in the public domain were used to modify the disease forecast, Simcast, one of the disease forecasts that is included in the DSS. Those modifications are listed in the following table.

Thresholds

Active Ingredients[1]			Thresholds						
			Susceptible		Moderately Susceptible		Moderately Resistant		Spray Interval
Active Ingredient 1	Active Ingredient 2	Product Example	Blight Units	Fungicide Units	Blight Units	Fungicide Units	Blight Units	Fungicide Units	minimum (days)[2]
copper hydroxide or coppe		Champ F	27	-13	32	-18	37	-23	5
chlorothalonil		Bravo WS	30	-15	35	-20	40	-25	5
cyazofamid		Ranman 400 SC	37	-18	42	-23	47	-28	7
fluazinam		Omega 500F	34	-15	39	-20	44	-25	7
zoxamide	mancozeb	Gavel 75 DF	34	-15	39	-20	44	-25	7
famoxadone	cymoxanil	Tanos DF	30	-15	35	-20	40	-25	5
mancozeb		Dithane DF	30	-15	35	-20	40	-25	3
pyraclostrobin		Cabrio EG(tomatoes)/	30	-15	35	-20	40	-25	5
cymoxanil		Curzate 60DF	30	-15	35	-20	40	-25	5
fenamidone		Reason 500 SC	30	-15	35	-20	40	-25	5
mandipropamide	difenoconazole	Revus Top	37	-18	42	-23	47	-28	7
mandipropamide		Revus	37	-18	42	-23	47	-28	5
metalaxyl-m (mefenoxam)	mancozeb	Ridomil Gold MZ	45	NA	50	NA	55	NA	14
metalaxyl-m (mefenoxam)	copper hydroxid	Ridomil Gold Copper	45	NA	50	NA	55	NA	14
metalaxyl-m (mefenoxam)	chlorothalonil	Ridomil Gold Bravo	45	NA	50	NA	55	NA	14
propamocarb hydroxhloride		Previcur Flex SC	37	-18	42	-23	47	-28	7
azoxystrobin		Quadris	30	-15	35	-20	40	-25	5(7)
azoxystrobin	chlorothalonil	Quadris Opti	30	-15	35	-20	40	-25	5
mono- and di- potassium s		Helena Prophyt	27	-15	32	-20	37	-25	5
mono- and di- potassium s	chlorothalonil	Catamaran	30	-15	35	-20	40	-25	5(7)
dimethomorph		Forum SC	30	-18	35	-23	40	-28	5
phosphorous acid		Phostrol	30	-18	35	-23	40	-28	4
trifloxystrobin		Flint (tomatoes)/Gem	27	-15	32	-20	37	-25	7
fluopicolide		Presidio	37	-18	42	-23	47	-28	7
fentin hydroxide (triphen		Super Tin 80 WP	30	-15	35	-20	40	-25	7
fluoxastrobin		Evito 480 SC	30	-15	35	-20	40	-25	7
maneb		Maneb 75 DF	30	-15	35	-20	40	-25	5(7)
metiram		Polyram 80 DF	30	-15	35	-20	40	-25	5

ii) Evaluate the resistance of important tomato cultivars to late blight in the field. Because Zach Hansen (working with Chris Smart) conducted an experiment on many cultivars of tomatoes, we did not duplicate his efforts, but rather assisted him and applied our energies to evaluations (see below).

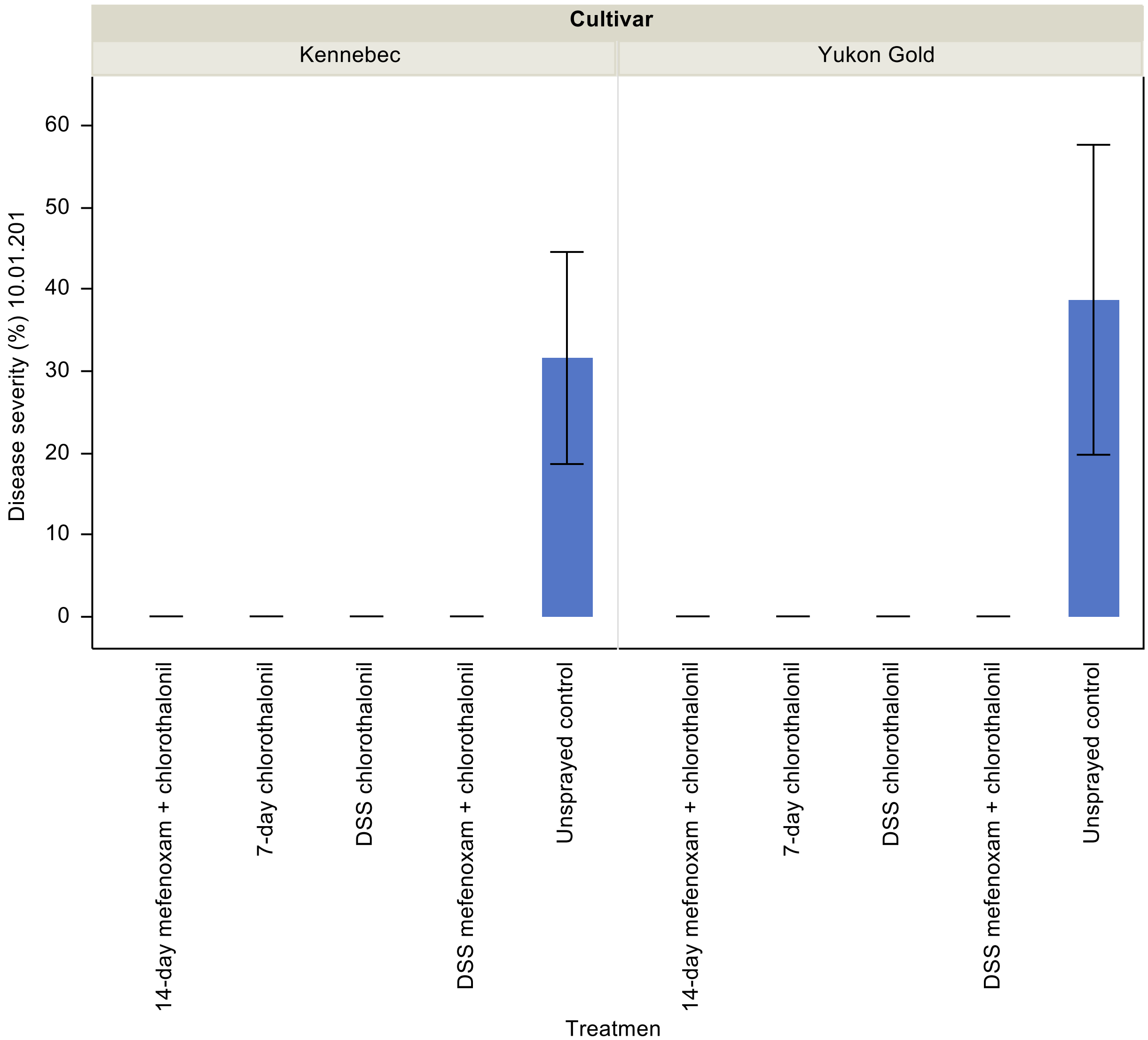
iii) Project evaluation.
These modifications described above were evaluated in a field experiment. The treatments were a) fungicide applications applied according to standard grower practice (weekly), b fungicide

applied according to the DSS with mefenoxam; c) fungicide applied according to the DSS without mefenoxam and d) no fungicide. Two different potato cultivars were included in the experiment; one was quite susceptible and the other was moderately resistant. The specific spray dates and spray amounts are identified in Table 2.

Table 2. Fungicide treatment programs

		Fungicide application									Disease severity
Treatment	**Cultivar**	**8/20**	**8/21**	**8/28**	**9/4**	**9/7**	**9/11**	**9/14**	**9/19**	**9/25**	**(%)**
7-day chlorothalonil	Kennebec		B	B	B		B		B	B	0.0003
DSS chlorothalonil	Kennebec			B				B		B	0.0000
DSS mefenoxam + chlorothalonil	Kennebec			M				B	M	B	0.0000
14-day mefenoxam + chlorothalonil	Kennebec		B	M	B		M		B	M	0.0000
Unsprayed control	Kennebec										31.6250
7-day chlorothalonil	Yukon Gold		B	B	B		B		B	B	0.0000
DSS chlorothalonil	Yukon Gold	B		B		B		B	B	B	0.0000
DSS mefenoxam + chlorothalonil	Yukon Gold	B		M		B		M	B	M	0.0000
14-day mefenoxam + chlorothalonil	Yukon Gold		B	M	B		M		B	M	0.0000
Unsprayed control	Yukon Gold										38.7500

One unscheduled application of mefenoxam + chlorothalonil was applied to the DSS mefenoxam + chlorothalonil treatment program for Yukon gold on 09/25



Summary

- All fungicide treatment programs were effective at preventing potato late blight (Figure).
- DSS scheduled fewer chlorothalonil applications (three sprays) when compared to the 7-day chlorothalonil schedule (six sprays) for the cultivar Kennebec (Table 2).
- DSS scheduled fewer chlorothalonil (two sprays) and mefenoxam + cholorothalonil applications (two sprays) when compared to the 14-day chlorothalonil (three sprays) and mefenoxam + chlorothalonil schedule (three sprays) for the cultivar Kennebec.
- An equal number of chlorothalonil applications (six sprays) were scheduled based on the DSS and 7-day spray schedules for the cultivar Yukon gold.
- For cultivar Yukon gold, the DSS scheduled three chlorothalonil and two mefenoxam + chlorothalonil applications as compared to the grower standard of three chlorothalonil and three mefenoxam + chlorothalonil applications based on the 14-day mefenoxam + chlorothalonil schedules.

- Disease progress on cultivar Yukon gold was limited by plant senescence.

This experiment clearly indicated that the DSS improves the "efficiency" of fungicide use – particularly when a somewhat resistant cultivar is used. Effective suppression of disease was achieved with the DSS and enables significant "savings" in terms of fungicide.

The improvements in the DSS have made the DSS much more useful to growers, because the most important fungicides are now included in the system. All tests of the system have demonstrated benefit in terms of excellent disease suppression and reduced usage of fungicide. We estimate that use of the system can lead to savings of 10-20% of current fungicide use. The addition of the most popular fungicides makes the system much more attractive to growers. Future efforts will focus on including the effects of resistance in diverse tomato cultivars.

9. Project Locations.

The experiments and evaluations occurred in Tompkins County.

10. Samples of Sources Developed:

The best illustration of the sources developed are at the following website: http://blight.eas.cornell.edu/blight/.